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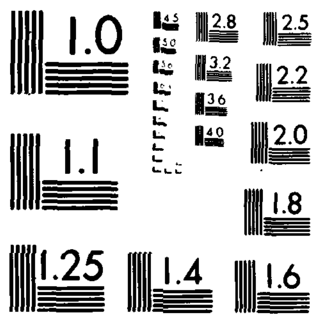

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A method of communication of hydrographic information is presented. Based on the DMAHTC Chart No. 1, a controlled vocabulary is used to create an algorithm by which information can be transferred in a language-independent, computer-compatible code. Using a specific nautical chart, a controlled vocabulary and this coding algorithm as parameters, a method is presented by which all members of the hydrographic community can share vital information such as Notice to Mariners, in a common format without the limitations imposed by a multiplicity of languages and chart formats.

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An Algorithm for Language-Independent Transfer of Hydrographic Information

8th Annual NOS Conference

Submitted by:
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DMAHTC

4076

Introduction

Since earliest days, man has tried to exploit the 70 percent of the Earth's surface covered by water. As soon as the first intrepid sailor ventured from the coast of Egypt, Phoenicia, or Mesopotamia, he discovered the need for a scientific study of the oceans, a study which continues to this day. Great strides have been made in collecting, evaluating, and verifying hydrographic information in the intervening centuries, particularly since the Challenger Expedition in 1876. It is now within the realm of technical possibility to sound any depth and determine any position with excellent accuracy, and to reshape the shoreline, and even to harness the currents.

Of essence in the advancement of all science, including hydrography, is the communication of information. Assume for a moment that the Vikings did, in fact, visit North America in the late 10th or early 11th century. A momentous discovery to be sure, but one which, in the absence of any clear proof, will always be qualified. Leif Ericsson, reportedly visited Newfoundland, and the Vikings might possibly have reached New England, yet Christopher Columbus gets all the real credit for discovering America. Why? Because his discoveries, even if they were not original, were communicated effectively throughout the known world. Without an effective system of communication any advance in technology or the sciences can spread only very slowly, if at all.

So it is with hydrographic and navigational discoveries. During the 16th and 17th centuries only Spain and Portugal had the information necessary to safely navigate to the Orient and back. Contained in books, much like our present day Sailing Directions, these "rutters", as they were called, were prized more highly than gold. The nation which controlled the routes controlled the trade and subsequently accumulated vast wealth.

Since then a spirit of cooperation has emerged out of a concern for the common welfare of mankind and concern for the lives and property involved in oceanic transit. Hydrographic information is no longer a state secret. Cooperation has allowed all maritime nations to conduct their international trade with a high degree of safety.

At issue is whether communication has kept pace with this expansion. Recent years have seen the advent of instantaneous worldwide communication by satellite. Computers are able to handle communications at speeds unimaginable a few years ago. Micrographics, lasers, and fiber optics all promise advances in the near future. But these technologies are not being fully exploited. Consider the Notice to Mariners, which will be the chief example of this report. At present, each of the various maritime nations produces a Notice which differs in format and, sometimes, language from all others. Each is printed on paper and distributed by mail. To be of use by another hydrographic activity each must be laboriously translated and evaluated.

What is proposed here is not intended to modify this existing system. Instead it is an attempt to use the Notice to Mariners as an example of how the fundamentals of Information Science can be applied to Hydrography. The merger of these disciplines is shown to provide a theoretical basis from which methods may be developed that will be useful in the communication of hydrographic information both nationally and internationally.

The system is designed to be flexible enough to allow a broad spectrum of the Hydrographic community to participate. The procedures will differ slightly, but information can be reported by a cooperating observer aboard a Naval or merchant ship, a member of a survey team, or an information specialist at a national hydrographic activity.

Information Science

It may be beneficial to briefly review the key elements of Information Science. Information Science is a relatively new discipline combining elements of: Computer Science, Library Science, Classification Theory, and Communication Theory. It attempts to define ways in which information can be defined, communicated, stored, retrieved, and otherwise manipulated.

Information is any fact, code, symbol, statistic, or message which has inherent meaning. Information is not to be confused with data; a data item or datum is, in itself, of little meaning. It must be interpreted and evaluated to be considered information.

An example may be useful to clarify the difference. Assume that you are driving a car as it approaches an intersection. On the right shoulder is an eight-sided roadsign, painted red with white lettering. Data elements are: sign, octagonal, red background, and white lettering; collectively these data are sufficient to convey meaning and are thus said to be information. The information is sufficient to trigger a response to the brain initiating a set of actions which stop the car.

Conversely, consider another example. Data elements are: sign, rectangular, white background, and black lettering. No response is triggered. The sign has no information content per se. It might indicate that the speed limit is X, that the fine for littering is Y, that the highway number is Z or so on. You must read the lettering printed there and interpret it for meaning and relevance to your present needs. If the data on the sign doesn't have meaning for you or if it doesn't reduce uncertainty, no information has been transferred.

Three points which are central to this discussion are suggested by the second roadsign. First, the shape and color of the sign are insufficient to convey meaning. It requires additional data for the sign to be useful. This is an important concept to which we will return. There is in every message a minimum number of symbols which are necessary to convey meaning. The system presented in this report attempts to reduce a hydrographic message to only this essential information.

Second, assume that the printing on the sign was incomprehensible or obliterated. Aside from providing one more distraction, the information the sign was intended to convey has been lost. The sign which told of the bridge around the next blind curve being washed out failed to warn of this danger, and thus the driver is unaware of it. And the next driver, and the next.

Like many early explorers these drivers can't benefit from the experience of others who have preceded them. Each driver has to navigate as well as he can. The sign did not communicate the information so there never really was any information.

Finally, suppose that the sign was clearly legible but in a language you did not understand. It carries no information for you. Even though it carried a sufficient, unambiguous message, it conveys no information to someone who doesn't know the code.

Alternatively, consider our stop sign again. The shape, the color, and the code are each sufficient to convey meaning. A white on red sign signals stop. An octagonal sign signals stop. To an English-speaking driver "stop" signals stop. The message is clear, all white on red signs are stop signs, all octagonal signs are stop signs. Even without the lettering, the sign is a symbol which has a clear meaning — STOP!

A key point in our discussion of information is that of uncertainty. Information reduces uncertainty, data does not. Information is unambiguous in form and does not introduce a possibility of misunderstanding or misinterpretation. A symbol in a message which carries an ambiguous meaning reduces the information content of the message.

In order to reduce the ambiguity of symbols in our everyday speech we add modifiers. Within the framework of grammar, modifiers reduce uncertainty and ambiguity. For example, it is possible to speak of a rock in terms of hydrography. As a term, "rock" is ambiguous. It requires modifiers to define it more clearly. It could be a rock above water, a rock which dries at certain stages of the tide (which must be specified), a rock awash at a specified datum, or a sunken rock which may or may not be dangerous as defined by depth and position. The modifiers must be present to define the rock.

Each hydrographic feature requires a specific set of modifiers to give it meaning. We have discussed rocks as an example but the same holds true to other features, such as buoys. Buoys can be a variety of shapes, colors or systems (Cardinal, Lateral, IALA, etc.). Depths, whether dragged or sounded, verified, or suspected, can be in fathoms, feet, meters, or shots of anchor chain. A feature has a specific, finite set of modifiers which it must have and no others. The use of modifiers can be said to be precontrolled.

Another fact must be kept in mind. The use of a natural language, i.e., one in actual spoken use such as English, French, Russian, or Japanese, introduces the nuance of grammar and usage to the words of any message. When a sailor gets ready to "hit the beach" we all know he's not preparing to box with a sand dune, but a word for word translation into Japanese might indicate this.

Nor is English free from ambiguity even in proper usage. Consider the simple declarative sentence: "She told me that she loved me." Now add the all-purpose modifier "only" anywhere in the sentence. In fact, it can be put in any place in the sentence and make sense alghough all of the possible sentences have slightly different meanings.

To eliminate confusion which can result from the use of a natural language, we may employ an artificially constructed language with a simple grammar which is rigidly adhered to.

Such an artificial language employs a limited or controlled vocabulary; as mentioned earlier this language is precontrolled. The vocabulary in this case consists of a number of words and symbols which should be immediately understandable to anyone in the Hydrographic community.

The grammar is controlled first, by limiting the message to 80 alphanumeric characters, this will allow the message or character-string to be transcribed and stored by computer. The reader may be aware that some computer systems will accept up to 120-character-string messages. Until such time as interactive terminals become widely available, however, an 80 character message should suffice.

The grammar is further controlled by assigning each of the 80 fields to a specific mode (alphabetic, numeric, or blank). Each field can have only certain defined values which will always mean the same thing. The grammar dictates the relative positions of the subject, object and action verbs of the message minimizing the confusion which occurs in natural languages.

Hydrographic Messages

The fundamental unit of this coding algorithm is the hydrographic message. By utilizing a common format, information can be freely communicated and clearly understood by all members of the Hydrographic community. We have examined the theoretical basis for using a controlled vocabulary approach with an artificial grammar, let us now examine in detail the prime elements of the message.

Chart Number-Subject

The first data-group on a message contains seven fields of alphanumeric characters and consists of the chart number. Most nautical chart (National Ocean Survey and Defense Mapping Agency Hydrographic/Topographic Center) numbers are six digits, the seventh field is reserved for use when the reported information falls on a plan or inset. On DMAHTC charts, and on most foreign charts of multiple plans, they are designated by letters A, B, C etc. Insets or undesignated plans must be indicated by thier position on the chart.

The coding rules are as follows:

<u>Fields 1-6</u> chart number 2 to 6 digits, left-justified and blank-filled.

<u>Field 7</u> plan designator, alphabetic A, B, C etc. or I if a single inset, or T-top, B-bottom, L-left, R-right if multiple undesignated insets.

For several reasons, the nautical chart was chosen as the base upon which all information will be reported. First, because this is the system currently in use for U.S. Notice to Mariners. Second, because this will allow Naval and merchant mariners to cooperate in reporting information. Survey information may also be reported in this manner, either on an existing chart or with a slight modification of the computer programs on the survey sheet.

Action Verb

The assumption is that any change to be made on a chart can be indicated by a single action verb. The verb is coded by a single numeric field giving a total of 10 possible verbs of which five are presently used at DMAHTC.

The coding is as follows:

1. Add
2. Change
3. Delete
4. Relocate
5. Substitute
6. -Ø Have not yet been assigned.

Chart Symbol-Object

The primary premises of this report are that: (1) it is possible to define any chart symbol by a three-symbol alphanumeric code; and (2) that chart corrections are modifications of the symbols which appear on a chart.

While the latter premise appears self-evident, it is nevertheless necessary. Since we have chosen the chart as the data base, we have reversed the traditional basis of reporting hydrographic information. The usual methodology of reporting utilizes the geographic position as a basis; e.g., the buoy in position N has been moved to position M, or the depth in position X is Y fathoms. This scheme proposes that reported information is best suited to update an existing data base; i.e., a *specific nautical chart.*

To return to our first premise, the three-symbol codes to be used will be essentially those in Chart No. 1, "Nautical Chart Symbols and Abbreviations." For example, if the reference is to a stranded wreck, the code would be 013. The code references the symbol, not the wreck itself.

In a similar way, any symbol can be coded by the originator of the message and decoded by the recipient. The advantage of the code over plain text is that there can be no question on the part of the recipient as to which of several classes of rocks or which of a score of buoy symbols was intended.

Decoding the message does require that an additional publication be used but this disadvantage is compensated by the increase in accuracy.

An additional, very important advantage of this system is that it is not language-bound. A non-English speaker can easily encode a message.

Position

Transmission of the geographic position is one part of a typical message which cannot be substantially reduced in length. It will require a maximum of 16 symbols to encode a position and this has been allocated.

The coding is as follows:

<u>Latitude</u> degrees (2), minutes (2), seconds (2) decimal (1)

<u>Longitude</u> degrees (3), minutes (2), seconds (2) decimal (1)

Quadrant (1).

The quadrant of the globe can be identified by a single digit:

1. North and West
2. North and East
3. South and West

4. South and East

5. cross Greenwich Meridian, West first

6. cross Equator North first

7. -Ø not assigned

Quadrant codes 5 and 6 are intended to be used when more than one position is necessary as in the case of an area, a cable or pipeline or a relocated aid when the positions fall in different quadrants.

Even though there are 16 fields allocated for the position, few occasions allow a determination to be made to this precision. Therefore, an adjustment will be allowed. Using an odd number of digits after the degrees will indicate that the last is a decimal; e.g., 653 is read as 65.3 degrees, 65233 is read as 65 degrees 23.3 minutes.

Position is to be left-justified and blank-filled if any sub-unit is not used. In time the system can be modified to accept variable length positions.

It may appear that describing the position in terms of quadrants is an unnecessary complication to replace two alphabetic characters with one digit. The intention is not to go to extremes to shorten the message, but to eliminate its dependence on language.

North, South, East, and West and their abbreviated forms are so familiar to us that we overlook the fact that they are English words. This coding algorithm has been designed to be, so far as possible, entirely free of any natural language so that it can be used effectively by anyone, whether he understands English or not. In fact, if a message is properly coded, it will be impossible to tell which language it was encoded from. This should be welcomed by bilingual countries such as Canada and Belgium, multilingual countries such as India, and by other countries such as the Netherlands and Denmark whose languages are in very limited use outside the country.

We shall now briefly examine some of the other elements which are necessary to the message.

Chart nationality (2 numeric)-since we have limited the chart number to 7 digits, it will be necessary to develop a code for the producer of the referenced chart. Up to 100 countries can be accommodated. This list has yet to be developed, but we can use ØØ for DMAHTC and Ø1 for NOS as an example.

Edition (6 numeric)-indicating the edition number (2) year (2) and month (2) of the chart being used.

Last Notice to Mariners (4 numeric)-notice number (2) and year (2) provides an audit trail to insure that all corrections to this chart have been received.

Chart No. 1 used (1 numeric)-rather than impose the use of the U.S. Chart No. 1, it is proposed that a message can be coded from any of 10 lists of chart symbols. If this system is to be accepted, a new chart symbol pamphlet will have to be produced by the participating country. In the interim, a transmitter must use one of the existing charts listed below. To be sure of being able to decode any message, a receiver would need all of these charts. This puts a burden on the receiver, but since only a national hydrographic activity would find it necessary to collect data from all sources, only they could find it necessary to carry a full complement of Chart No. 1s.

The coding is as follows:

1. I.H.O.
2. British Admiralty
3. Canada
4. France
5. Germany, Federal Republic
6. Japan
7. Spain

8. U.S.A.

9. U.S.S.R.

Ø not assigned

This concludes the listing of elements common to all reports. A brief review shows that we have assigned the first fields as follows:

1-7	Chart number
8-9	Nationality of chart producer
10-15	Chart edition
16-19	Last Notice to Mariners
20	Action verb
21	Chart 1 used for encoding
22-25	Chart symbol
26	Quadrant
27-42	Position
43-80	Flags, details, and text.

Flags, details, and text will consume a large portion of some messages and less for others. An in-depth analysis is beyond the scope of this report; additional work has to be done. At the present time, however, we can examine the scope of the problem and identify areas where details must be settled.

First, definitions of the terms are in order. A flag is used here in the data processing sense, certain numbers in certain positions will trigger or flag the computer program to take certain actions. For instance, action verb 4 (Relocate) always indicates that there will be a second geographic position in the message. A chart symbol Q (Soundings) will indicate that the numeric value of the sounding will be included. It is expected that these flags will be written into the computer programs to manipulate the messages. If programs are properly written these flags should be user transparent; that is, the user need not worry about them.

Details are those data which are needed to complete the message such as the second position and the sounding value.

Text is that portion of a message which cannot be coded. The use of quotation marks in the message will indicate that everything within is to be printed as is. Text will include proper names, morse code characteristics of radiobeacons, notes, warnings, and legends not included in the symbol codes. While textual information is, no doubt, important, it will usually be in the language of the chart producer and thus subject to the problems related to natural language.

The following is an overview of details which have been identified. The "If-then" statements should be familiar to any computer programmer and should serve as an example of how the programs can be written.

<u>Action Verbs</u>

If 2 Change, then further details are required

If 4 Relocate, then two positions are required

If 5 Substitute, then two symbols are required

<u>Chart Symbols</u>

If A Coastline, then multiple positions are required

If C Land Features, then multiple positions are required

If D Control point, then elevations may be required

If E Units, then quantity is required

If G Ports and Harbors,

6-11 piers, jetties etc., then two positions are required

12-13, 46, 49-51 areas, then four or more positions are required.

If H Topography, then at least two positions are required

*If K Lights, then K10-13 (position) is required as are characteristic K21-26 and color K61-67.

*If L Buoys, then type 1-33 and color 41-48

*If a message refers to a light or buoy, additional coding is required.

If M Radio and Radar Stations, then characteristic signal and frequency are required.

If O Dangers, then depths may be required.

If P Various Limits, then multiple positions may be required.

If Q Soundings, then values of sounding are required. Unit of Measure will be the same as chart.

If R Depth Contours, then multiple positions are required.

Returning to the coding of the message, starting at the next open field (43), we find our flags as we read from left to right. If the action verb is Relocate, we have identified the chart symbol so we can assign the next 16 fields (43-57) for the second geographic position. In a like manner, if the action verb is Substitute we can assign the next 3 fields (43-45) to the second chart symbol.

Action verbs Add and Delete do not automatically require details; they take their keys from the chart symbol.

The Change verb will usually refer to some existing detail on the chart; e.g., light characteristic, buoy, color, radiobeacon frequency, etc. In this case the reference chart symbol should be the symbol to appear on the chart, and details should begin in field 43.

Lights and buoys are the primary object of the Change verb and are the features least easily coded from the existing Chart No. 1. The coding algorithm below is proposed as a partial solution to this problem.

Knn indicates a light.

First digit indicates type of light.

1-. any light symbol

2-. light symbol with riprap surrounding

3-. aero light

4-. light beacon

5-. light vessel

6-. light with obscured sector(s)

7-. range or leading light

8-. sector light

9-. leading light

Second digit is unassigned at this time. In the event a suitable second key can be devised, it can be implemented at some point in the future. At present this field equals Ø.

The use of any K symbol is a flag for details in the following order:

(A) Characteristic (n numeric)

(B) Color (1 numeric)

(C) Period, in seconds (2 numeric)

(D) Notes (2 numeric)

Characteristics are coded as follows:

01. F, fixed

02 Fl, flashing

03 OCC, occulting

04-n unassigned

The (A) Characteristic field is of variable length to allow for group characteristics such as group flashing (3 & 2). Characteristic is left-justified on field 42 and terminated by a single blank.

Color is coded as follows:

1. amber or yellow
2, blue
3. green
4. orange
5. red
6. white
7. black
8, Ø not assigned

This color coding is also used with buoys and beacons.

Period in seconds is self-explanatory.

Notes are assorted text such as "Exiting" and "destr" which appear under K in Chart No. 1. They are coded the same as any other chart symbol except that they do not take a K in this position.

Light code K80, sectors, sets a flag for an additional group. Sectors are coded: color code (1 numeric), arc (3 numeric, 000°-360°). Any arc not assigned is assumed to be white.

Obscured sector takes the same form; color code, arc, except that color code, if not otherwise noted, is presumed to be an obscured portion.

If any of these details cannot be determined, this can be indicated by leaving a blank.

If any details cannot be coded from the above tables, they can be included as text, for instance light vessel "Borkum Riff" or "Nantucket."

Buoys present a less challenging but, nevertheless, troublesome problem. There are a number of different symbols in use for each type of buoy. If one symbol can be decided upon, then it will eliminate confusion. At present Chart No. 1 lists symbols for 33 different types of buoys, and the list appears adequate enough to allow coding by this algorithm (Lnn). A buoy does require details, primarily color, but also topmarks and radar reflectors.

As mentioned earlier, buoys can use the same color codes as lights with the exception that two fields must be allotted to allow for the large number of two-color buoys. When, as in the case of a junction or danger buoy, the color of the top band makes a difference, it is given first.

This algorithm is an attempt to formalize all hydrographic messages in a rigid, logical, albeit, somewhat complicated manner. Each code group represents specific information dependent for its meaning on the groups which precede it.

You will note that an area symbol will trigger a flag to require one or more positions in the details section, a depth symbol to require a discrete number and so on. There will be occasions where a message will be longer than 80 characters. In such cases there must be some method of continuing the message. Therefore, we shall introduce the final two codes which are primarily for record-keeping purposes.

Correction number (2 numeric) is to be used primarily by producers of Notice to Mariners, to indicate, for example, that this is the 76th correction to this edition of the Chart.

This code is optional, and if used it is preceded by a non-alphanumeric character such as a comma in field 76.

End of character-string (1 numeric) is always used and field 80 is reserved for it. It is coded as follows:

Ø end of message

1 additional

This concludes my discussion of the coding algorithm itself. The balance of my remarks will address implementation.

Implementation

The coding algorithm may seem, from the text, to be quite complicated. In fact, it isn't. It is no more complicated than the scheme in use for U.S. Notice to Mariners and immeasurably less complicated than plain English.

It will, of course, be necessary to prepare a coding guide for users of this system. Anyone who has ever been a weather observer aboard ship, and those from NOS who are familiar with the data collection program for weather, can visualize just such a guide which has been in common use for many years.

NOAA's weather report collection program enlists the assistance of cooperating weather observers on board ships. I can recall filling out coding sheets many times. Even without knowing anything about computers, the guide takes the observer through the report in a logical, step-by-step procedure and allows him to encode a great deal of information on a single line on a coding sheet.

At the same time the coding guide is prepared, the Chart No. 1 can be revised eliminating unnecessary symbols and providing each useful symbol with a discrete number.

Once these tasks are accomplished, a test period can take place. Messages can be coded and decoded by hand and compared. If no information is lost or garbled, then the computer programs can be written.

The computer programs need not be very sophisticated. This algorithm was developed with the computer in mind; nothing should present any difficulties for a working programmer, particularly one who is skilled in writing in COBOL.

Conclusion

The chief value of this system, indeed its only real usefulness, lies in its use as a kind of "lingua franca" for the hydrographic community. A century or more ago all diplomacy in Europe was conducted in French. Similarly, English is the universal language of commercial air transport; a French airliner landing in Istanbul communicates with the tower in English. To communicate hydrographic information effectively, a common language is needed. It is to this need for a common language that this report is addressed; such a common language is possible. Whether it is this algorithm, some variation of it, or a completely different scheme is of little consequence as long as the old parochial communication methods are allowed to become extinct.

A modern communication algorithm will allow hydrographic messages to be transmitted by radio, telephone, or telex. Consider, on the other hand, the delays inherent in the present system. A message, in this case a Notice to Mariners, is laboriously written out, edited, typed, set in type, printed, bundled, mailed, sorted at the receiving end, delivered to the proper office (hopefully), and laboriously translated word by word if not sent to a translator (involving most of the same steps again). Is a month to six weeks sufficiently fast communication for information this vital? I think not!

The world is now entering the Information Age, which many have compared to the Industrial Revolution. This is, perhaps, overstating the fact a bit, but the Hydrographic community must exploit the new information technology.